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ABSTRACT

Fifty-eight undergraduates took part in an experiment evaluating a full-spectrum light closely approximating natural sunlight and a cool-white fluorescent light commonly used in institutional settings. Four classes of a single teaching assistant were used and each class was compared against itself under different lighting conditions. Data were gathered during each seminar (with videotapes) and after each seminar (with questionnaires). The results show that there was no differential effect in self-reported attitudes or videotaped behavior attributable to the respective lighting conditions. At the end of the experiment students were asked to judge the respective lights on 20 dimensions and express their overall preference for one light or the other. No significant overall preference was shown; however, there was a clear difference in the qualitative characteristics of the lights when direct observations and appraisals were made. (Author/MLP)

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INTRODUCTION

An evaluation of human performance related to the human environment in an educational setting.
-Robert Bartholomew

Although the physiological responses of the individual to light in the environment seem to have been investigated adequately, little research has been undertaken to understand man's psychological reactions to light. To answer this question effectively, research must move beyond the physical factors of eye mechanics and the visual task into the arena of the perceptual/psychological processes which affect behavior. Harmon (1950) considers this aspect when he writes that "glare free task lighting and good eyes do not automatically convert the optical stimulus into meaningful symbols. These take form and meaning only through the experiences of the organism."

Reactions to Variations in Artificial Lighting

A light (Vita-Lite) which approximates the spectral energy of sunlight has been developed by the Duro-Test Corporation of North Bergen, New Jersey and was selected for use in the present study. It is a commercial fluorescent lamp, of conventional geometry, designed to duplicate sun and sky radiation at a temperature of 5500K. This is the environmental light composition which has influenced biological action spectra on the earth's surface. The literature review in this section described research with artificial sunlight lamps which have produced significant responses in plants and animals when compared with conventional interior light sources (i.e., other fluorescent and incandescent lights).

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Eating habits, weight gain and other physiological development have resulted from being under such artificial lighting conditions.

Fluorescent sunlight lamps were compared to standard fluorescent lamps in a study of the long-term effects upon Russian School children by Zamkova and Krivitskaya (1965). They found more favorable effects upon the health and physical development of the children under the artificial sunlight source. The pupils exposed to the sunlight lamps had a shorter reaction time to light and sound, were less easily fatigued, and showed an improved working capacity. The improvement of their academic standing was felt to be related to the favorable physical health factors.

Lighting in Education Settings

In an investigation to determine the relative merits of natural daylight and artificial light Hammel and Johnson (1956) examined schools with lighting systems utilizing natural daylight and artificial light in a variety of design: glass block, plastic domes, clerestories, overhangs and windows. They concluded that artificial light, properly utilized, is less expensive, more uniform and comfortable, and more adaptable to modern teaching techniques than daylight. Other studies in this area have not been carefully done. Manning (1967) summarized the problems associated with the current practice of working from a largely intuitive understanding rather than basing design decisions on empirical research, and stressed the need for understanding (1) the purpose and (2) the subjective qualities of school environments.

Group Organization

An interdisciplinary group composed of designers, psychologists and an illuminating engineer composed the evaluation team.

Method

Experimental Conditions

A seminar room was equipped with two independent fluorescent light sources, only one of which was "on" in any given seminar hour. The first, "Vita-Lite," was a full-spectrum light closely approximating natural sunlight. The second was the standard cool-white fluorescent light commonly used in institutional settings. The physical structures of the lamps are identical, but they are distinctly different in the color of the light they emit. This difference, however, is not so perceptible as to make the Vita-Lite appear noticeably different to a naive person upon entering the room.

The care with which the experimental conditions (i.e., the different light sources) were disguised is evidenced by the fact that only one subject indicated (on a follow-up questionnaire) that he was aware of the changing lighting conditions during the duration of the experiment.

Subjects

Fifty-eight undergraduates in an introductory psychology course at Cornell University representing a broad cross-section of student interests and backgrounds and sex took part in the experiment.

Design

In educational research it is frequently the case that teacher and class effects are not controlled. In order to hold teacher characteristics and subject matter constant in this study, four classes of a single teaching assistant were used. In the design represented, each class was compared against itself under different lighting conditions in the subsequent or preceding week (thus avoiding the problem of interclass differences). The balancing of conditions effectively reduces the problems of order and serial position effects (e.g., fatigue, practice) in the experimental paradigm.

According to the design, data were gathered during each seminar (with videotapes) and after each seminar (with questionnaires). The blanaced pattern was extended from four weeks to eight for the purpose of increasing the amount of data gathered under the respective conditions and thus increasing the power of the statistical procedures employed.

Procedure

Except for the project directors, all the subjects and all others involved in data collection (i.e., the teacher and the raters) were kept naive to the experimental conditions.

Three cameras were mounted in the upper middle of three of the four classroom walls. While the students generally felt that "Big Brother was watching" when they first entered the room, the cameras lost their more obvious obtrusiveness within a short while, and as evidenced by the videotapes, the great majority of students adapted

to them by the second week. The cameras were remotely operated by a technician in the control room who had television receivers to monitor the activity in the classroom.

Measures

A Post-Seminar Questionnaire consisted of twenty bipolar scales on which each subject was to judge his reaction to the class, the quality of the seminar and the atmosphere of the room. The items used a five point scale ranging from one identifiable end of a dimension to another, in a form somewhat similar to the semantic differential.

An additional open response item was added primarily for the purpose of giving subjects a feeling of freedom of expression on the questionnaire; it was also used as a source of data where appropriate.

Classroom interaction was analyzed by an observational system for coding spontaneous verbal communication, useful in this case for describing the patterns of communication occurring under the different light sources. To accomplish this kind of observation it was necessary to select videotaped behavior patterns which could be identified and categorized for tabulation and graphic presentation.

A system of interaction analysis based upon the methods devised to fit the needs of this specific study. Categories of student and teacher behavior were developed which would allow for quantification of original and digressive contributions, and positive and negative affect in the communication. A form was designed for recording the frequency of various types of communications. Using maps of the room

the observers tracked the number and direction of verbal exchanges between subjects, and the overall pattern of interaction. This resulted in measures of amount of interaction, patterns of communication, and amount of non-teacher-directed interaction.

The observers were seven undergraduates and one graduate student who were members of a psychology seminar class taught by one of the principle investigators. They spend six weeks learning the category system and practicing with the recording procedures and sociogram systems. At the end of this period their ratings were checked for reliability.

Six other members of the psychology seminar were responsible for graphic presentation of the data. The quantity and pattern of interaction were described graphically on a map of the room noting the seat location of participants. Black sociograms were used to present data for the cool-white light condition and orange sociograms were used to present data for the Vita-Lite condition.

The graphic System, allows for relational comprehension of the linear data. Superimposing the four cool-white and the four Vita-Lite sheets from one class eight sociograms, one can make a visual comparison of the data. Comparisons can also be made of all four classes in one week, or of the total cool-white and Vita-Lite conditions.

The results show quite clearly that there was no differential effect in self-reported attitudes attributable to the respective lighting conditions. Only one variable, the cool-warm dimension, approaches statistical significance, and the fact that it stands alone suggests that it probably represents the influence of chance factors.

The videotape data--reflecting the quantity and quality of interaction--were also analyzed with a graphic procedure that further demonstrates no overall differences in verbal interaction between the conditions. It does, however, show week to week fluctuations more clearly.

An examination of the transparencies suggests that if the analysis had been done on classes three and four alone, the results may have shown the Vita-Lite condition to indeed be more stimulating. While such qualifications are not generally considered acceptable practices from a statistical standpoint, a closer look at the patterns of interaction of the four classes indicates that there was more interaction and a greater number of patterns of interaction in classes three and four than in classes one and two regardless of the lighting condition.

The implication posed by this visual analysis is that perhaps there needs to be some minimum level of interaction before varying environmental conditions such as lighting can have demonstrable effects. Further research designed to examine more complexities in the relationship between behavior and the classroom environment is required.

Post-Experiment Appraisal of Conditions

At the end of the experiment, the investigator returned for the purpose of debriefing the subjects. This included revelation of the experimental conditions, explanation of the purpose of the research, description of discussion of the experiment however, and before the differences in the lights were discussed, students in each class were asked to judge the respective lights on twenty dimensions.

The format of this short questionnaire was similar to the one the students filled out daily during the course of the experiment, so little explanation was needed. So that order effects were controlled for, presentation was balanced across the four classes. Classes one and four were shown the cool-white light first and two and three were shown the Vita-Lite first. The light shown first was on from the beginning of class so as not to give away the conditions prematurely. To avoid influencing the subjects by the names of the lights, they were referred to as "X" and "Y".

The results: Vita-Lite was characterized by appearance as being brighter, stronger, more exciting, lively and stimulating, as well as clearer and more pure. In contrast, the cool-white light was perceived as being warmer, softer, quieter and more pleasing, restful and unobtrusive than Vita-Lite. Vita-Lite was described as being more distracting and irritating while the cool-white light was considered more boring.

It is interesting to note that while colors were seen as more vibrant, and complexions more natural, under Vita-Lite, the actual light of cool-white was described as more natural. Given the spectral distribution of Vita-Lite as being similar to that of natural sunlight, one would have predicted just the opposite result. The explanation probably lies, however, in the fact that cool-white is the standard light for a classroom setting, and, therefore, the Vita-Lite would seem less natural in the sense that it was more unusual for the particular environmental setting. The fact that Vita-Lite was described as clearer and more pure suggests that it is indeed perceived as having "natural" qualities.

Additional comments implying that the cool-white light was more restful but also dull and that Vita-Lite was more stimulating, but also harsh are presented in Appendix G.

After the comparisons were made, students were asked to judge their overall preference for one light or the other. On a five point scale of preference for light X to light Y the mean was 2.95, indicating no significant overall preference for one light or the other.[1]

The overall suggestion of these results is that while there was a negligible differential effect on mood, classroom performance, and classroom interaction from the lighting conditions, there is a clear difference in the qualitative characteristics of the conditions when direct observations and appraisals are made.

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[1]In computation, the scale scores were standardized so that Vita-Lite was at the 5 end and cool-white was at the 1 end of the scale.

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